Retrofitting at scale

BUILDINGS & CITIES

SPECIAL COLLECTION: RETROFIT AT SCALE: ACCELERATING CAPABILITIES FOR DOMESTIC BUILDING STOCKS

RESEARCH

Retrofitting at scale: comparing transition experiments in Scotland and the Netherlands

PETRA HOFMAN
FAYE WADE
JANETTE WEBB
MARTIJN GROENLEER

**Author affiliations can be found in the back matter of this article*

ubiquity press

ABSTRACT

New approaches are needed to achieve the scale and standard of building retrofit required to meet climate targets. Transition experiments are innovation projects that take a societal challenge as their starting point; they can be both top-down (government led) and bottom-up (civil society led). However, such experiments often remain isolated events that have little impact on delivering systemic change. There is limited knowledge on why this is so and what can be done to increase the success of experiments. The paper therefore compares the top-down approach to piloting Local Heat and Energy Efficiency Strategies (LHEES) in Scotland with the bottom-up strategy used for the Social Innovation Labs for a Zero Energy Housing Stock (SMILE) in the Netherlands. The different approaches are compared using three mechanisms to characterise systemic change: deepening, broadening and scaling up. Using data from interviews with local authority and citizen actors, the paper shows that neither top-down nor bottom-up experiments are sufficient in themselves to foster the new norms, information-sharing or legislative mechanisms needed to reach climate targets. The paper specifies elements of top-down and bottom-up experiments which can usefully be incorporated for achieving systemic change in energy retrofitting.

POLICY RELEVANCE

Delivering building retrofit at scale is crucial to net zero greenhouse gas emissions targets. Policymakers can benefit from adopting long-term strategic approaches to retrofitting, incorporating leadership from local actors. Central government coordination is essential to providing a clear programme and timetable for local actors to coalesce around. In addition, localised projects need to be shared and supported through centrally coordinated repositories and knowledge exchange. Policymakers must develop complementary policies designed to improve support from both governmental and non-governmental

CORRESPONDING AUTHOR:
Faye Wade
School of Social and Political Science, University of Edinburgh, Edinburgh, UK
faye.wade@ed.ac.uk

KEYWORDS:
capabilities; housing; innovation; local authority; public policy; retrofit; urban lab; the Netherlands; UK

TO CITE THIS ARTICLE:
Hofman, P., Wade, F., Webb, J., & Groenleer, M. (2021). Retrofitting at scale: comparing transition experiments in Scotland and the Netherlands. *Buildings and Cities*, 2(1), pp.637–654. DOI: *https://doi.org/10.5334/bc.98*

actors. This will include planning and citizen engagement, managed at a local level; this is crucial for retrofitting buildings, which affects everyone directly. Neither top-down nor bottom-up approaches are sufficient in themselves to deliver systemic change in retrofitting. Central coordination, together with local planning and public engagement, will provide more opportunities to deliver retrofit at the speed and scale necessary for meeting climate targets.

1. INTRODUCTION

A major contribution to reaching the goals of the Paris Agreement must come from retrofitting buildings to decrease the need for energy for heating and cooling (CCC 2019). Despite developing policy and incentives, no European country has yet created an approach adequate to deliver retrofitting at the scale and standard needed (Rosenow *et al.* 2017). Delivering deep renovation of the existing building stock by 2050 remains a major challenge for the UK and European Union (EU) (BPIE 2013: 52).

As a response, researchers and policymakers have been advocating experimental approaches. These can be conceived as transition experiments, or activities that seek to explore how societal problems can be overcome through 'learning by doing' rather than having a predefined result or (technical) solution at the outset (Van den Bosch & Rotmans 2008: 17). For energy retrofitting, there is good reason for such experiments to focus on the local level. Retrofitting schemes customised to localities can be more successful than generalised nationwide strategies (Gillich *et al.* 2018). The spatial embeddedness of buildings together with place-based cultures mean that distinctive insights into energy transitions can be generated at the local level (Bridge *et al.* 2013: 338). Local knowledge, including energy geographies (*e.g.* energy assets) and information about the building stock, owners and occupants, can be crucial for successful implementation of energy efficiency and heat decarbonisation. Significantly, different local, material characteristics require different strategies for energy transitions (Kuzemko & Britton 2020). For these reasons, local and regional authorities are considered 'well placed to drive and influence emissions reductions' (CCC 2019: 127), not least through their ability to coordinate energy retrofitting at scale. In addition, local authorities, community organisations and energy cooperatives can normalise retrofitting: setting an example through retrofitting their own building stock (Castán Broto 2012); encouraging wider uptake (Bartiaux *et al.* 2014); raising awareness among local communities (Kivimaa *et al.* 2019); and helping to foster homeowners' trust in private contractors (de Wilde & Spaargaren 2019).

Consequently, regions with varied energy governance frameworks and policies have been implementing experiments for locally coordinated energy retrofitting. These are aimed at creating systemic change in the way that energy retrofitting takes place, with a view to delivering low carbon building stock and heat (or cooling) infrastructure. These transition experiments can be both top-down (led by central government) and bottom-up (led by civil society, citizen groups and local non-governmental organisations.

Transition experiments have been recognised for their contribution to understanding 'what works' for systemic change and scaling (Van den Bosch 2010; Van den Bosch & Rotmans 2008; Moore *et al.* 2015). They are expected to contest business as usual and provoke change by shifting expectations, understandings of the problem, standards and practices (Loorbach & Rotmans 2006). Despite these high expectations, experimental approaches for delivering retrofit at scale have thus far had limited impact.

Experiments often remain isolated events that have little impact on incumbent regimes and delivering change at scale (Hoogma *et al.* 2002). Often, once an experiment is finalised, no actors have, or recognise that they have, responsibility for continuing the 'project'. For example, when experiments incorporate a coordinating role for local governments, the reality is often that

limited stakeholders are included in participative processes, restricting the impact and legitimacy (Gustafsson *et al.* 2015). Further, inconsistency in support from central governments can mean that local authorities struggle to engage and have to determine their own levels of ambition (Collins 2020; Tingey & Webb 2020). In addition, responding to national goals in ways that reflect local socio-spatial and political economic interests is a significant challenge (Moss *et al.* 2014; Collins 2020). Experiments thus end up as projects in themselves rather than processes that mature and develop on a continual basis (Gustafsson *et al.* 2015).

Disappointing outcomes from central government-led (top-down) experiments have resulted in experiments led by local actors (bottom-up), and vice versa. However, both bottom-up and top-down experiments continue to be limited in their ability to deliver systemic change. This leads to the research question:

> In what ways do top-down and bottom-up transition experiments contribute to scaling processes for delivering systemic change in energy retrofit?

To address this question, the paper examines top-down and bottom-up experiments in Scotland and the Netherlands. National policy ambitions in Scotland and the Netherlands both include energy retrofitting and reducing the reliance on natural gas across all building sectors. In both countries, local authorities are anticipated to play a coordinating role. In Scotland, experiments are being implemented top-down by the Scottish government: Local Heat and Energy Efficiency Strategies (LHEES) are being proposed as a statutory duty for local authorities to deliver area-based plans for energy efficiency and heat decarbonisation. In the Netherlands, Social Innovation Labs for a Zero Energy Housing Stock (SMILE) are being implemented bottom-up by local and regional actors coordinating to build capacity for local, participatory, area-based approaches to retrofitting and decarbonisation of the existing housing stock. Both experiments are exploring roles of local actors in delivering systemic change.

The urgency of delivering heat decarbonisation and energy efficiency across the building stock makes it imperative that such experiments for delivering retrofit at scale succeed. By comparing these cases, this paper improves understanding of how different types of transition experiment contribute to processes of scaling and why they fail to deliver the expected systemic change.

The paper is structured as follows. Section 2 reviews the literature on transition experiments and identifies a framework of three mechanisms through which they might support systemic change: broadening, deepening and scaling up. Section 3 outlines the research design, provides detail on the experiments studied in the Netherlands and Scotland, and describes the method. Section 4 presents the results, comparing the design and implementation of the experiments and their potential contribution to broadening, deepening and scaling up. The discussion in Section 5 contrasts the contribution of top-down and bottom-up transition experiments to accelerating change. This concludes with recommendations for academics and policymakers seeking to develop the design and implementation of transition experiments for delivering systemic change in building retrofit.

2. TRANSITION EXPERIMENTS

2.1 EXPECTED OUTCOME OF TRANSITION EXPERIMENTS: SYSTEMIC CHANGE

Transitions are major, non-linear changes in societal cultures, structures and practices (Grin *et al.* 2011). These can be viewed as a shift from one dynamic equilibrium to another. Energy transitions have often been conceptualised using the multilevel perspective (MLP) (Rip & Kemp 1998; Geels 2002). In this, new approaches are developed within niches, or protected innovation spaces. Their success is governed by interaction with regime (socio-technical configurations, practices and established rules) and landscape levels (factors such as macro-political developments). The MLP thus simplifies complex interlocking institutions and social dynamics, but offers a useful heuristic tool for targeting research comparisons and providing insights into potential routes to change. However, much of the earlier transitions literature focused on major technological transformations in the way a societal function is fulfilled.

Seeking to address this limitation, Van den Bosch & Rotmans (2008) introduced the concept of 'transition experiments' to represent innovation projects that take a *societal challenge* as their starting point. Transition experiments consider how societal problems can be overcome, rather than having a predefined result or solution (such as a new technology) at the outset. Sengers *et al.* (2019: 153) define an experiment as:

> an inclusive, practice-based and challenge-led initiative, which is designed to promote system innovation through social learning under conditions of uncertainty and ambiguity.

2.2 HOW EXPERIMENTS DELIVER SYSTEMIC CHANGE: PROCESSES OF SCALING

Van den Bosch & Rotmans (2008) have proposed three 'mechanisms' through which transition experiments can be instrumental in systemic change: deepening, broadening and scaling up. This framework is used in the paper because of its potential utility in exploring mechanisms through which transition experiments might achieve change at the regime level (Laakso *et al.* 2017). Deepening, broadening and scaling up, as conceptualised here, are all likely to be needed for systemic change in retrofitting. However, it is currently unclear how these mechanisms are reflected in the design and implementation of top-down and bottom-up transition experiments. The three mechanisms are now described in more detail, along with the types of strategies that have been proposed to stimulate them.

Deepening refers to the notion that durable change has been achieved only when 'people's hearts and minds, their values and cultural practices, and the quality of relationships they have, are transformed' (Moore *et al.* 2015: 74). This acknowledges that culture plays a powerful role in shifting problem domains. Deepening includes local shifts in ways of thinking, values and perspectives (culture), changes in habits and routines (practices), and shifts in organising the physical, institutional or economic context (structure) (Van den Bosch & Rotmans 2008). *Strategies for deepening* include processes through which actors can learn as much as possible about a transition experiment within a specific context (*e.g.* through a pilot) (Van den Bosch & Rotmans 2008) and reframing stories to change beliefs and norms (Moore *et al.* 2015: 77). Deepening can be encouraged by providing (financial, juridical and mental) space for conducting transition experiments; by providing support to overcome barriers; and by incorporating monitoring and evaluation (Sengers *et al.* 2019).

Broadening refers to replication by repeating or dispersing an innovation geographically to greater numbers. This does not have to be direct replication, but can include 'taking the essence of a concept' and spreading it through different routes (Omann *et al.* 2020: 757). *Strategies for broadening* can include incubating ideas, the co-generation of knowledge, training or inspiring others to adopt an innovation in their context. The use of information-sharing and learning platforms can be particularly important here (Moore *et al.* 2015). For example, both social media and early cooperation between local and central government were essential for successful broadening in the case of a bike-sharing scheme (Omann *et al.* 2020). Broadening can be supported by providing resources to replicate new practices in different contexts; by facilitating interactions between similar experiments; by stimulating network building; and by sharing learning experiences (Sengers *et al.* 2019).

Scaling up is based on the recognition that innovative approaches must be codified in law, policy and institutions (Douthwaite *et al.* 2003; Van den Bosch & Rotmans 2008). Previous transition experiments have highlighted that a focus on the policy level has 'the largest impact' and is the way to change the 'rules of the game' (Moore *et al.* 2015: 74). *Strategies for scaling up* include new policy development, partnering and advocacy. Scaling up can be enhanced by selecting and supporting frontrunners with the motivation and ability to experiment and scale up; by balancing between providing protection from the regime and directly involving regime actors who have the willingness and power to change existing structures; and by actively feeding back learning experiences to the regime (Van den Bosch 2010: 187).

2.3 TYPES OF TRANSITION EXPERIMENTS

Both top-down (government-led) and bottom-up (civil society-led) transition experiments have been trialled. Top-down and bottom-up approaches both have challenges in terms of scaling and delivering systemic change. Top-down experiments, led by central governments, include devolving powers from national to local levels, and seeking to incorporate local knowledge into decision-making (Sturzaker & Gordon 2017: 1326). Such approaches often aim to support evidence-based development of governance and legislation (Annala *et al.* 2016), and hold appeal in their ability to test policies and participatory approaches under real-world conditions (Laakso *et al.* 2017). Bottom-up approaches, led by civil society, incorporate novel forms of social organisation, often led by citizen groups and local non-governmental organisations (Hegger *et al.* 2007; Seyfang & Smith 2007). These activities are often conceived as emerging from citizen initiatives and operating in the margins of mainstream regimes (Seyfang & Smith 2007), but they are often supported by funding from central governments. Such activities can put pressure on incumbent institutional actors and lead to wider changes, *e.g.* bottom-up experimentation initiated a system-wide change towards renewables in Germany (Fuchs & Hinderer 2016).

Figure 1 illustrates the distinction between *type* of experiment and *processes of scaling*; it also highlights *outcomes* of such experiments. This distinction is valuable for understanding how experimental design (top-down versus bottom-up) can contribute to processes of scaling and subsequent outcomes for retrofitting at scale. This framework is now operationalised for analysing distinct transition experiments in Scotland and the Netherlands.

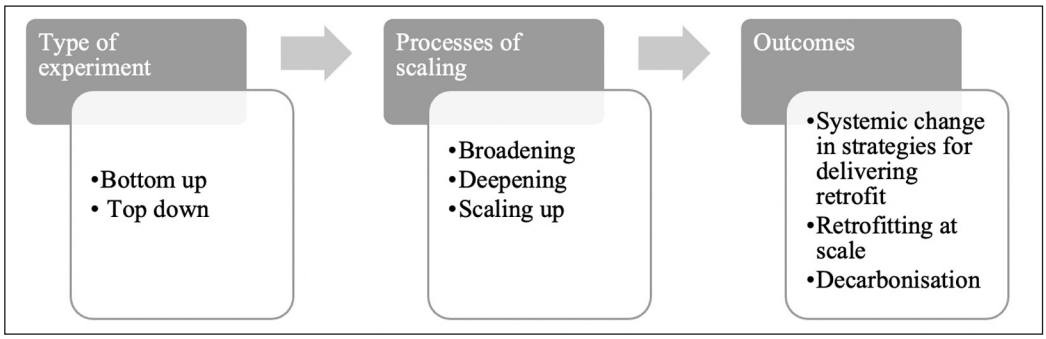

Figure 1: Framework distinguishing types of transition experiment from processes of scaling and intended outcomes.

3. RESEARCH DESIGN, CASES AND METHODS

3.1 RESEARCH DESIGN

A comparative design is used to study two cases: Scotland's pilots for Local Heat and Energy Efficiency Strategies (LHEES), which are being developed through a top-down approach; and in the Netherlands, Social Innovation Labs for a Zero Energy Housing Stock (SMILE), which has emerged through a bottom-up approach. The two cases were selected because both are pursuing decentralised governance to support energy retrofitting at scale. In both countries, these experiments are socio-technical, challenge-led and practice-based, with a view to developing social learning, and as such can be classed as transition experiments (Sengers *et al.* 2019). The two experiments are now described in more detail.

3.2 SCOTLAND: PILOTING LHEES

UK devolution, initiated in 1998, transferred state powers from the UK Parliament to the Scottish Parliament (along with equivalents in Wales and Northern Ireland) (UK Parliament n.d.). Scotland has powers over local government, housing, economic development and the environment, which allows the Scottish government to develop retrofitting strategies distinct from those in other parts of the UK. One example is the Scottish government's Energy Efficient Scotland programme, introduced in 2016 (Scottish Government 2018). This is the first national-scale cross-sector building retrofit programme in Scotland; however, it takes a distinctly local approach to delivery,

with responsibility largely placed with individual local authorities. This programme provides the basis for the LHEES discussed here.

Introduced in 2017, LHEES are intended to establish area-based, costed plans and priorities for systematically improving the energy efficiency of all buildings, and decarbonising heat. This is cross-sector; it includes local authority-owned buildings (council buildings, schools, libraries, social housing), but also private properties (owner-occupied, privately rented and the commercial sector). LHEES is the only experiment of this type in Scotland. They are currently in development through pilots, but the Scottish government is proposing that they become a statutory duty for local authorities (Scottish Government 2017, 2021). Statutory duties are the main tool used in the UK to allocate responsibility and some administrative authority to local government (Kuzemko & Britton 2020). The exact nature of this potential statutory duty is not yet clear, and discussions between the Scottish government and local authorities are ongoing.

Within the LHEES pilots, the Scottish government has encouraged the pursuit of 'low regrets'[1] solutions for heat decarbonisation, including heat pumps and district heating networks (CCC 2016). The Scottish government (2017: 11) outlined the process for developing LHEES as including:

- an assessment of existing local and national strategies and data availability
- an authority-wide assessment of the existing building stock's energy performance and heat supply
- an authority-wide setting of aggregate targets for heat demand reduction and decarbonisation of buildings—short and long terms
- a socio-economic assessment of potential energy efficiency and heat decarbonisation solutions
- the selection of areas/prioritisation of opportunities leading to the designation of zones
- the costing and phasing of delivery programmes.

There are uncertainties about the process, *e.g.* what 'zones' might look like is unclear, and elements, such as a tool to support socio-economic assessment, are still in development. However, the Scottish government is clear that the programme is about the delivery of tangible solutions: through this process, it is intended that local authorities will develop a strategy, to be delivered over the next 20 years. Between September 2017 and September 2020, all 32 of Scotland's local authorities have taken part in one of three LHEES pilot rounds. Each local authority was awarded between £50,000 and £70,000 for the pilot, and required to produce an LHEES report. The Scottish government's stipulated aims for these transition experiments were to test and develop methods, identify relevant sources of data, and understand the capabilities required to deliver LHEES. Local authorities specified the focus of their pilots, including the area covered and sector focus (see Appendix 1 in the supplemental data online for a summary). At this development stage, the LHEES pilots offer an opportunity to explore the contribution of this top-down approach to scaling energy retrofitting. This transition experiment has an explicit learning element: a formal research evaluation of the processes and outcomes of developing LHEES (Wade *et al*. 2019; Wade & Webb 2020). The empirical material for this paper is drawn from this evaluation, and is detailed in Section 4.

3.3 THE NETHERLANDS: SMILE

The Netherlands has introduced the Dutch Climate Agreement and Climate Law, which puts local authorities in a coordinating role for implementing local heat and energy strategies (Klimaatakkoord 2019, Rijksoverheid Nederland 2020). In parallel, across the Netherlands there are numerous efforts with local actors such as authorities, energy system operators, citizen energy initiatives, energy intermediaries, social housing associations and local communities undertaking initiatives to develop and implement plans for reducing greenhouse gas emissions and increasing energy efficiency that fit local characteristics and challenges. One of these initiatives is Social Innovation Labs for a Zero Energy Housing Stock (SMILE).

SMILE, in Noord Brabant, was initiated by actors brought together in a regional agreement for retrofitting at scale, signed in 2015 (Hart van Brabant 2015). The project emerged in 2017

in response to local disappointment about the results of nationally coordinated innovation programmes, such as Energiesprong (Ministerie van Binnenlandse Zaken en Koninkrijsrelaties 2011; PBL 2014). It responds to global and national goals by pursuing retrofit of the existing housing stock, and by trying to improve societal acceptance of, and citizen participation in, the heat and energy transition.

The project is a space for experimentation, learning and innovation in the governance of the energy and heat transition in which actors pursued local, participative, area-oriented approaches. SMILE pilots involve several steps:

- The selection of neighbourhoods based on neighbourhood criteria and stakeholder analysis.
- An assessment of potential solutions for buildings and energy infrastructures per neighbourhood.
- An assessment of local citizens' perspectives on the heat and energy transition.
- Developing a participatory planning and implementation process.
- The implementation of low carbon energy measures.

The project has run 10 pilots in different Noord Brabant neighbourhoods between 2017 and December 2020. The exact nature of these pilots varies, as detailed in Appendix 2 in the supplemental data online.

With the SMILE pilots, regional partners intended to work from the bottom-up to prove energy efficiency and decarbonisation to be feasible and affordable. They sought to connect realities in neighbourhoods and villages to (technological) innovation and climate goals. The idea is that taking the neighbourhood or village as a starting point increases the chance that emergent cooperatives among neighbours be given a role and place in policy and implementation.

3.4 METHOD

The LHEES and SMILE cases are analysed using qualitative, exploratory research. Qualitative research provides in-depth analysis of practices and perspectives, and has been used extensively for engaging with local actors involved in energy transitions. It allows direct engagement with those participating in and delivering experiments; this is important as participants' conceptions of success may be different to those of scholars or other evaluators (Collins 2020). It enables a reflexive perspective on the experiments in the context of retrofitting at scale and developing governance. The method brings together existing datasets from two research projects: the evaluation of LHEES pilots in Scotland and a research project monitoring and evaluating SMILE in the Netherlands.

In the Scottish case, data were primarily collected through 21 semi-structured interviews conducted between 2018 and 2020 with all local teams taking part in the first and second round of LHEES pilots. Appendix 1 in the supplemental data online includes a summary of the aims of LHEES pilots managed by each participating local authority. A condition of pilot funding was participation in interviews as part of a wider evaluation. Local authority project leads were the primary interviewees; these were identified from funding application documents. These individuals identified additional colleagues to join the interviews, where appropriate. Consequently, the interviews included between two and four local authority officers, and some included consultant partners. The participants were mostly in energy and climate change or housing roles. Interviews lasted between 45 and 90 minutes and were primarily conducted in local authority offices; some interviews were conducted via Skype or phone, because of distance and time limitations. All interviews were completed before the Covid-19 pandemic. The interview schedule is included in Appendix 3 in the supplemental data online; this considered the scope and content of the pilot; the activities involved in developing an LHEES; and the skills and resources required. The interviews formed part of a wider evaluation project (Wade *et al.* 2019; Wade & Webb 2020), which also included a review of each local authority's initial application materials and final report.

In the Dutch case, data were primarily collected through 13 semi-structured interviews, two stocktake sessions and one closing session conducted between 2018 and 2020, all with respondents taking part in the SMILE project. The stocktake and closing sessions brought together

participants and major project stakeholders for sharing, accountability, and reflection on activities and progress. Appendix 2 in the supplemental data online includes a summary of the SMILE pilots managed by each participating local actor group. Participants agreed upon engaging in the research activities as part of the project; these included local authority officers, consultants and active citizens. Interviews were held with individual respondents. The interviews lasted between 60 and 90 minutes and were conducted via Microsoft Teams because of restrictions due to Covid-19. The interview schedule is included in Appendix 4 in the supplemental data online. The first two stocktake sessions were held at a public location in the city of Tilburg and the closing session was organised via Zoom. These interviews and sessions formed part of a wider research project (Hofman & Groenleer 2021), which also included participatory observation, focus groups and a review of project documents.

To comply with ethics and data protection requirements, all participants were anonymised in the presentation of data. In both cases, documents and interview transcripts were stored and coded using NVivo. Data analysis followed a deductive process of the authors returning to and coding the existing data based on the notions of deepening, broadening and scaling up. Following an iterative process, the authors discussed their data and understandings of the different transition experiments, and revisited their data to interrogate and narrow emerging points of comparison.

4. RESULTS

4.1 PROCESSES OF SCALING FOR A TOP-DOWN TRANSITION EXPERIMENT: LHEES PILOTS

4.1.1 Deepening: new practices and cultural change

LHEES require collating data held by different local authority departments. For example, combining data held in a business department with that managed by a housing department. For several councils, the pilots prompted experimentation with more holistic cross-departmental working practices. This was a means to overcome the siloed local authority structures regarded as a barrier: 'Inter-departmental collaboration [and] multi-disciplinary type work inside the council [...] doesn't happen that much' (local authority housing lead). However, holistic working did not emerge in all cases, with some local officers noting that colleagues 'lacked the time to participate' and were sometimes reluctant to share data due to privacy and quality concerns. Thus, the pilots alone were insufficient to deepen and normalise cross-departmental working cultures within local authorities.

The implementation of LHEES is likely to require the prioritisation of energy projects within local authorities, in part through a culture shift led by senior management and elected members. Whilst some participants noted that elected members were 'really supportive' and 'optimistic' about the LHEES pilots, others explained that elected members were not engaged:

> It's been really difficult to even get heads of services to get involved [...] it's not a priority for them until we've got something significant in front of them.
>
> (local authority sustainability lead)

Thus, the LHEES pilots themselves were not significant enough to engage senior management and elected members. Without such 'buy-in', it will be difficult for these transition experiments to deepen new working norms.

Additionally, the collation and analysis of data was outsourced to consultants during the pilots. Such outsourcing is common practice in resource-constrained local authorities. Consultants were procured centrally either by the Scottish government or by the local authorities themselves:

> We were prescribed the process of going out to tender for a consultant to undertake the majority of the work.
>
> (local authority energy lead)

This outsourcing could reinforce the development of expertise amongst consultants, rather than the local authority officers who are intended to have ultimate responsibility for LHEES. Arguably, a strategic and holistic approach for retrofitting at scale will require resources for the development of expertise within local authorities.

4.1.2 Broadening: diffusion of new approaches

The Scottish government had an intentional 'broadening' approach to the LHEES pilots, with all 32 of Scotland's local authorities trialling LHEES across the three rounds of pilots. Although these pilots usually only captured part of each local authority's building stock, all participants were able to develop some understanding of the process involved in developing LHEES.

Although the Scottish government set up workshops during the pilots, several participants noted that they lacked the time and resources to attend, and so missed opportunities for sharing. As an alternative, an online information-sharing board (Trello) was set up by one local authority; however, this was not used by all participants, and was not maintained over time. Instead, participants noted their reliance on existing networks to learn about progress with other LHEES pilots. These included an existing Borderlands Initiative between councils in the south of Scotland, and the Cities Alliance which includes Scotland's five city councils. Where participants did have opportunities to engage, they found these useful:

> We'd hoped to get a feel for how off-grid rural communities might work [...] at least learn the principles. [A colleague at another council] said [their trial] is not quite what they hoped it was going to be [...] so I think we've all learned an awful lot from it.
>
> (local authority sustainable development manager)

> When I heard about the community consultation exercise that [another council] completed, I thought I would have liked that. [...] Looking forward that's something that I'd want to build upon.
>
> (local authority sustainability & climate change manager)

Thus, sharing knowledge and experiences has been beneficial for shaping local authorities' management of the pilots, and future LHEES work. However, this spreading of LHEES principles was challenging where local authorities are pursuing locally appropriate technical solutions. For example, one officer noted that lots of other councils had 'a similar approach' to one another with a focus on district heating, whilst they were pursuing an electric heat-pump solution. This limited the potential for the co-generation of knowledge with other local authorities, but did allow officers to learn about the technologies most suitable for their own regions. Despite regional specificities, where neighbouring local authorities share traits in their geography and built environment, it may be beneficial to collaborate.

4.1.3 Scaling up: mainstreaming by partnering, codification in law, policy and institutions

Partnering and collaboration across organisations can be crucial for scaling up. For LHEES, this will require the sharing of data and eventual commitment for support from organisations across the energy sector. For example, one participant highlighted that a wider LHEES-style approach would increase their ability to engage broader stakeholders, including electricity distribution network operators (DNOs). Collaboration with powerful stakeholders, such as DNOs, is essential for accommodating changes in the grid from the rollout of electrical heating solutions.

Retrofitting is sector wide, and such partnering is also essential with local citizens and businesses. Despite this, most LHEES pilots did not include active engagement with local communities. This was attributed, in part, to not wanting to raise expectations amongst residents for something that may not happen. For example, one officer noted:

> It still seems a bit up in the air [...] it's almost like I'm waiting for someone to tell me 'you can share this now', and then I will.
>
> (local authority corporate asset and energy manager)

Thus, participants agreed that having the statutory duty in place would be crucial for providing certainty before engagement with local residents.

However, participants also highlighted that the statutory duty alone is unlikely to be sufficient. Across all the interviews participants emphasised that, as a result of long-term reductions in local authority budgets, they would be unable to deliver LHEES unless the statutory duty was

accompanied by additional resource, *e.g.* to cover an officer's time. In keeping with this, pilot participants highlighted confusion over the exact requirements of this potential statutory duty. For example, a local authority officer noted:

> We know they're looking at making it statutory but making what statutory? [...] if [the Scottish government] say 'we've got a Heat Networks Bill going through. We want you to do as much district heating as you possible' [...] then we'll go and sit in the corner [and not participate].
>
> (local authority housing lead)

The Scottish government's Heat Networks Bill is designed to support and encourage the development of district heating. Although essential for encouraging certain aspects of LHEES, this Bill was not seen to be of use for this participant, where the relatively dispersed distribution of properties in their authority area made heat networks unsuitable. Thus, a suite of legislation that supports different socio-technical solutions will be required for scaling up planning informed by LHEES.

4.2 PROCESSES OF SCALING FOR A BOTTOM-UP TRANSITION EXPERIMENT: SMILE

4.2.1 Deepening: new practices and cultural change

The relatively small-scale and bottom-up character of the SMILE project allowed for mental and organisational space to experiment:

> You can just experiment. There is not a deadline of a week, you can just go and investigate and immerse yourself. You come into different settings and find out, this fits or this does not fit. Or who will join and who will drop out, and you let that grow and develop.
>
> (local project team member and active citizen)

The flexibility of the SMILE projects allowed for the inclusion of additional voices, which in turn supported the reframing of stories for delivering building retrofit. In one example, the municipality wanted to explore the conditions under which low-income homeowners were willing and able to participate in planned retrofitting schemes:

> By offering eight low income households tailor-made solutions for energy retrofit, we might solve something for them, learn as much as possible and consequently be able to develop an arrangement for a substantial number of home owners in [the region] to have them say 'yes'.
>
> (local authority project coordinator)

In this case, a personal and intensive approach to citizen engagement facilitated individual low-income families in their decision to undertake energy retrofit and enabled them with tailor-made financial schemes. This inclusive approach led to mutual learning. In one case, a citizen group was keen to understand the underlying problems and goals for decarbonised heat and energy efficiency, and to ensure a transparent process. When the local authority officer presented three (technical) scenarios, a citizen group not only negotiated to gain an insight into the basis on which these were selected, but also to broaden the scope of the study. The group also studied European and national climate policies, laws and regulations, and was very aware of their position. The local authority officer expressed to have learned a great deal—to his surprise—from this citizen group. Similarly, in another case, collective learning with the local community led to reframing the issue of retrofit to a broader vision on a sustainable environment in which energy efficiency, energy production, heat decarbonisation, biodiversity and landscape must all be given a place. However, project participants expressed that they found it difficult to share their learnings among their wider organisations and networks:

> I've tried embedding in our organisation for a while now, but that is my biggest concern [...] to what extent can we really share this with other people in the organization. [...] I am afraid that basically everyone has to learn their own lessons in the coming years [...].
>
> (local authority project coordinator)

4.2.2 Broadening: diffusion of new approaches

Project partners, two local authorities, a regional authority, a university, a business partner, an independent research consultant and a community energy initiative all expressed a desire to learn about 'what works' in accelerating energy efficiency and decarbonisation.

> The idea was that we would look at different ways [to] shape and accelerate the energy transition. We looked at a number of criteria on the basis of which you could then compare [...] different neighbourhoods, [...] And that was the original idea, everyone does something different, and we move on from that.
>
> (project participant and independent research consultant)

While it was clear from the beginning that 'controlling' the environment as a 'lab' would be impossible, the different perspectives and institutional contexts of the participants made it even more difficult to structure the process. Indeed, sharing approaches and implementing them across pilots was particularly challenging:

> It went quite well at a local level, but at a regional level that learning capacity mainly came from the university partner. I always had the idea that the transfer from one neighbourhood to another was not automatic.
>
> (local authority energy lead)

To support this transfer of knowledge, during the project regular regional lab sessions (a space for co-learning and co-creating) were organised to learn about peers' experiences. In addition, two stocktakes were organised in which all experimental approaches were presented to broader stakeholders such as citizens, consultants and politicians:

> I liked that very much because you get completely different information. Even then when we all sat in the [venue], I found that a very valuable [session]. I was also looking back at that information. [...] And I am really curious about how that has developed further.
>
> (local project team member and active citizen)

Despite the popularity of these sessions, there was a recurring call for sharing tools and information. In addition, some of the participants were very critical about co-learning and co-creation within context of the project:

> In the month that I delivered the report, a project group was formed and that project group then started without any knowledge of the piece. It was never forwarded by those who had it. They weren't using it at all, they just started over.
>
> (project participant and independent research consultant)

4.2.3 Scaling up: mainstreaming by partnering, codification in law, policy and institutions

The involvement of higher management and government varied between pilots, as well as processes to engage them. It was difficult to directly engage national policymakers in learning activities, *e.g.* the stocktake sessions and dissemination process during the project. However, the project did manage to involve some key stakeholders, such as the network operator:

> If I just look at the network operator purely, I really think that they are starting to play their role better and better [...] whether that came through SMILE or the entire movement that surrounds it, I think that's really great how they eventually did that.
>
> (local authority energy lead)

Influencing policy development and processes of scaling up is potentially taking place through individual participants motivated and able to contribute to scaling up. Scaling up can be connected to an ability to learn and intermediate across levels, and the continuous interaction between policy development and societal development:

> What you are slowly seeing, and SMILE has contributed to that, is now with the plans that are being made, they suddenly see, 'hey, gosh, we have to cooperate a lot more on the (sub)regional level'.
>
> (local authority energy lead)

However, adopting insights from bottom-up experiments directly into new local policies proved difficult: even though some pilots were successful, the results were contested by local authority officers for being too time-consuming and expensive.

The Dutch SMILE project was implemented against a background of new policies and instruments at a national level. Governance instruments, policy and legislation in the Netherlands acknowledge the importance of citizen participation, and local and regional authorities are making an effort to include this in their planning processes, policymaking and implementation.

5. DISCUSSION

Despite numerous efforts, both top-down and bottom-up transition experiments show disappointing results in actually delivering energy retrofitting at the speed and volume necessary for meeting climate targets. There is little understanding of how to shape these experiments in such a way that processes of scaling can be achieved for systemic change. To address this, the paper has compared two distinct transition experiments: LHEES pilots, which followed a top-down approach in Scotland; and SMILE, which followed a bottom-up approach in the Netherlands. This discussion first details the outcomes of these experiments, before exploring their contributions to deepening, broadening and scaling up. Here, the discussion considers how the framework used can be developed to inform the design of transition experiments for energy retrofit, and support new ways of understanding scaling processes.

5.1 OUTCOMES OF TRANSITION EXPERIMENTS: TOWARDS SYSTEMIC CHANGE

5.1.1 LHEES outcomes

The LHEES pilots resulted in a series of reports: these provide analyses of the building stock in specific areas and, in most cases, costed projections for implementing energy retrofit and low carbon heating systems (primarily heat pumps and district heating networks). Local authority participants expressed a desire to develop these into costed plans for their entire local authority area. However, three years after its introduction, there is still contention over whether LHEES will become a statutory duty, and supporting legislation (*e.g.* the Heat Networks Bill) is slow to develop. Further, there has been no commitment from central government for long-term financial investment to support resource for this work within local authorities. Thus, systemic change in planning for energy retrofit at scale has not yet been realised.

5.1.2 SMILE outcomes

The SMILE outcomes are very diverse. In several neighbourhoods some small-scale but deep retrofits have been realised. These provide exemplary projects and opportunities for learning what works. In other cases, emergent cooperation amongst neighbours has led to more structural collaboration with local government and actors, including consultants, grid operators and housing organisations. It also resulted in the development of formal and informal strategies for decarbonisation. There are no further plans to develop SMILE as such, but actors pursue the replication of outcomes of individual pilots. To what extent this experiment contributes to systemic change and retrofitting at scale remains to be seen.

5.2 DEVELOPING UNDERSTANDINGS OF SCALING PROCESSES FOR ACHIEVING SYSTEMIC CHANGE

Limitations and strengths of these two experimental approaches have been revealed through three mechanisms: deepening, broadening and scaling up (Van den Bosch & Rotmans 2008). These are summarised in ***Table 1***, along with suggestions for how elements of the two approaches may be

merged for future experiments to deliver systemic change. This analysis has shown that these 'mechanisms' have social life and the interactions on which societal problem-solving depends at their centre. Although this framework has been a valuable heuristic device, the mechanistic language used could stand to eradicate some of this complexity. In addition, the extent to which processes of deepening, broadening and scaling up can actually be governed as such experiments emerge to inform systemic change needs to be considered. A consequent suggestion for developing this framework is to explore how the processual and dynamic nature of experimenting for transitions might be better captured. Indeed, socio-political processes have been core in shaping deepening, broadening and scaling up processes in both transition experiments.

Deepening suggests that scaling a transition experiment will only be achieved with the development of new cultures, norms and practices. In Scotland, the LHEES pilots offered an opportunity to trial new cultures of cross-departmental working in local authorities. However, the outsourcing of data analysis fostered the development of expertise within consulting organisations. Conversely, SMILE in the Netherlands created capacity for community involvement, resulting in the inclusion of broader perspectives. Such community involvement is likely to be crucial for efforts to deepen, which will depend on developing a balance between new practices and local priorities (Omann *et al.* 2020).

Broadening seeks to capture the importance of sharing lessons and the co-generation of knowledge. Information-sharing and the co-generation of knowledge was challenging in both cases. Lessons from the LHEES pilots were collated through evaluation reports (Wade *et al.* 2019; Wade & Webb 2020); however, local authority participants reported limited opportunities to share information with one another. In the Netherlands, regional lab sessions and stocktakes were organised to learn about project peers' experiences, and to disseminate lessons and experiences, respectively. However, local actors mostly focused on implementing their local project; there was no explicit strategy for replication here. Thus, supporting transition experiments to deliver systemic change will require the development and maintenance of shared repositories and ongoing information-sharing opportunities, which take multiple formats.

With regard to *scaling up*, the SMILE experiment lacked direct engagement with national policymakers. However, the project did partner with stakeholders who were in a position to influence policy on a regional and local level, although these approaches were sometimes challenged. For example, the involvement of community actors was contested by some local authorities for being expensive and time costly. In Scotland, there is recognition of the need to codify LHEES in law, with this currently being proposed as a statutory duty, although this is still in contention. There were also serious concerns amongst local authority participants that a statutory duty will not succeed if not accompanied by additional resource, in the form of finance for staff. This is essential for ensuring that strategic planning within local authorities for wide-scale retrofit can be realised.

PROCESS OF SCALING		TOP-DOWN EXPERIMENT: INSIGHTS FROM LHEES	BOTTOM-UP EXPERIMENT: INSIGHTS FROM SMILE
Deepening: new practices and cultural change	Contribution to deepening	• Pilots centrally coordinated and funded • Local authorities clearly identified as delivery actors • Opportunity to trial new ways of working	• Involvement of a variety of actors provided opportunities for broadening focus and social learning
	Risks to deepening	• Lack of support from senior management can limit the potential to embed new working cultures • Outsourcing limits the generation of knowledge within local authorities	• Difficult to engage all actors in collective learning processes • Lack of clarity and coordination on overarching goals and processes
	Suggested approach	• Central coordination provides clear overarching goals and focus • Create space for the inclusion of voices across levels: incorporating local and national priorities together • Ensure that those tasked with coordinating experiments are resourced to engage in them	

(Contd.)

PROCESS OF SCALING		TOP-DOWN EXPERIMENT: INSIGHTS FROM LHEES	BOTTOM-UP EXPERIMENT: INSIGHTS FROM SMILE
Broadening: diffusion of new approaches	Contribution to broadening	• 'Intentional broadening': with all local authorities receiving funding for pilots	• Regular regional lab sessions and stocktakes as platforms for sharing and co-generation of knowledge
	Risks to broadening	• Limited resource within local authorities restricted opportunities to participate in knowledge-exchange activities • Locally tailored solutions are not generalisable	• Insufficient sharing tools are made available • No explicit strategy or resources for potential replication • Local actors mostly focused on implementing local project: different aims may make replication more difficult
	Suggested approach	• Coordinated approach to information-sharing; incorporate multiple platforms (information repositories and verbal exchange) • Provide resources to ensure that experiment participants have the capacity to engage in learning opportunities • Identify core aspects of experiments that are generally replicable and ensure that these are shared; allow for locally tailored solutions to emerge from here	
Scaling up: mainstreaming by partnering, codification in law, policy and institutions	Contribution to scaling up	• Scottish government has an ongoing desire to develop LHEES as a statutory duty • Systematic piloting and evaluation of the results • Scale of pilots allowed for the incorporation of varied stakeholders, *e.g.* distribution network operators (DNOs)	• Partnering with specific actors who can influence policies and practice at local and regional levels
	Risks to scaling-up	• Limited partnering with local businesses and citizens • Ongoing tension over the development of statutory duty • Lack of commitment for additional supporting resources for local authorities to deliver LHEES	• Difficulty in engaging with national policymakers • Limited strategy or capacity for advocacy and policy development in project
	Suggested approach	• Provide a long-term commitment for ongoing resources after initial experiments are complete • Ensure a sufficient scale of piloting to secure the attention of the multitude of actors that will be required to engage	

Table 1: How Local Heat and Energy Efficiency Strategies (LHEES) and Social Innovation Labs for a Zero Energy Housing Stock (SMILE) have contributed to and risked processes of deepening, broadening and scaling up, and suggested approaches for future transition experiments.

Note: Summarised are the ways in which these top-down and bottom-up experiments have contributed to and potentially risked processes of deepening, broadening and scaling up. Through this, a series of suggested approaches for the design of future transition experiments is identified, with a view to delivering systemic change.

Further research should include longitudinal analysis of LHEES and SMILE, and their long-term contribution to systemic change in the delivery of building retrofit. In particular, this needs to include the measurement of scaling impacts. For energy retrofitting activities, such measurement might incorporate the number of treated buildings by sector; the number of low carbon heating systems installed; the total financial investment; and carbon emissions reductions. The contributions, risks and suggested approaches outlined in ***Table 1*** are useful for policymakers and local actors in designing and implementing future transition experiments. In turn, these hybrid experiments need to be subject to in-depth analysis to refine the experimental approach and ensure success in delivering systemic change.

6. CONCLUSIONS

The top-down Local Heat and Energy Efficiency Strategies (LHEES) pilots offered the opportunity for *deepening* through testing new, more holistic ways of working within local authorities. However, relying on outsourcing simultaneously restricted opportunities to develop the local knowledge necessary for wide-scale retrofitting. Through involving citizen and local communities, the bottom-up Social Innovation Labs for a Zero Energy Housing Stock (SMILE) pilots fostered *deepening* through incorporating local engagement, but this also revealed tensions between policy processes and the potential for tailoring to local needs. Neither project provided strategies

consistent or wide-reaching enough for successfully *broadening* new ways of working. The Scottish government's top-down initiation and coordination of the LHEES pilots means that lessons could contribute to *scaling up* through informing policy and legislation. In contrast, learnings from the bottom-up SMILE project are not being systematically included in larger programmes or policy processes. Elements of both are required for developing transition experiments that can deliver the systemic change so urgently needed for retrofitting at scale.

NOTE

1 'Low regrets' is the term used by the Climate Change Committee (CCC) to denote retrofitting measures that 'are sensible regardless of the longer-term path' (CCC 2016: 8). This means those that will deliver carbon emissions reductions and energy efficiency improvements regardless of choices made about larger, system-wide interventions such as incorporating hydrogen into the gas network.

ACKNOWLEDGEMENTS

The authors thank the editor and co-guest editors of the special issue for creating the intellectual space for this contribution. They are grateful to the three anonymous reviewers whose insightful comments helped to strengthen the paper.

AUTHOR AFFILIATIONS

Petra Hofman *orcid.org/0000-0001-9677-5166*
Department of Public Law and Governance, Tilburg Law School, Tilburg University, the Netherlands

Faye Wade *orcid.org/0000-0003-4590-652X*
Sociology, School of Social and Political Science, University of Edinburgh, UK

Janette Webb *orcid.org/0000-0001-8295-346X*
Sociology, School of Social and Political Science, University of Edinburgh, UK

Martijn Groenleer *orcid.org/0000-0002-3262-9968*
Department of Public Law and Governance, Tilburg Law School, Tilburg University, the Netherlands

COMPETING INTERESTS

The authors have no competing interests to declare.

DATA AVAILABILITY

The data used in this paper are primarily transcripts of interviews; these are not publicly available. Although the authors would like to be able to make these public, the research funding did not include resources to be used for the extensive work involved in translating and anonymising the materials.

ETHICAL APPROVAL

The Scotland study received ethical approval from the University of Edinburgh. For both studies, all participation was voluntary, and interview recordings and transcripts were developed with the participants' consent. In line with data protection requirements, all participants have been anonymised throughout this manuscript.

FUNDING

The Scotland study was funded by a Climate Change 2016–2020 postdoctoral fellowship: Evaluation of Energy Efficient Scotland. The authors are grateful to the Scottish government and local authority officers who facilitated and participated in this research. The Netherlands study

was funded by the European Regional Development Fund (ERDF), OP Zuid and the Province of Noord Brabant. The authors are grateful to the project partners and all participants in the research.

SUPPLEMENTAL DATA

Supplemental data for this article can be accessed at: *https://doi.org/10.5334/bc.98.s1*

REFERENCES

Annala, S., Viljainen, S., Pakkanen, M., & **Hukki, K.** (2016). Consumer preferences in engaging in a sustainable lifestyle. *International Journal of Innovation and Sustainable Development*, 10(1). DOI: *https://doi.org/10.1504/IJISD.2016.073411*

Bartiaux, F., Gram-Hanssen, K., Fonseca, P., Ozolina, L., & **Christensen, T. H.** (2014). A practice–theory approach to homeowners' energy retrofits in four European areas. *Building Research & Information*, 42(4), 525–538. DOI: *https://doi.org/10.1080/09613218.2014.900253*

BPIE. (2013). *Boosting building renovation. An overview of good practice: Renovation requirements, long-term plans and support programmes in the EU and other selected regions*. Buildings Performance Institute Europe (BPIE). *https://bpie.eu/wp-content/uploads/2015/10/Boosting_building_renovation_-_Good_practices_BPIE_2013_small.pdf*

Bridge, G., Bouzarovski, S., Bradshaw, M., & **Eyre, N. C.** (2013). Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy*, 53(C), 331–340. DOI: *https://doi.org/10.1016/j.enpol.2012.10.066*

Castán Broto, V. (2012). Social housing and low carbon transitions in Ljubljana, Slovenia. *Environmental Innovation & Societal Transitions*, 2, 82–97. DOI: *https://doi.org/10.1016/j.eist.2012.01.001*

CCC. (2016). *Next steps for UK heat policy*. Climate Change Committee (CCC). *https://www.theccc.org.uk/publication/next-steps-for-uk-heat-policy/*

CCC. (2019). *UK housing: fit for the future?* Climate Change Committee (CCC). *https://www.theccc.org.uk/publication/uk-housing-fit-for-the-future/*

Collins, B. (2020). 'It's not talked about': The risk of failure in practice in sustainability experiments. *Environmental Innovation and Societal Transitions*, *35*, 77–87. DOI: *https://doi.org/10.1016/j.eist.2020.02.008*

de Wilde, M., & **Spaargaren, G.** (2019). Designing trust: how strategic intermediaries choreograph homeowners' low-carbon retrofit experience. *Building Research & Information*, 47(4), 362–374. DOI: *https://doi.org/10.1080/09613218.2018.1443256*

Douthwaite, B., Kuby, T., van de Fliert, E., & **Schulz, S.** (2003). Impact pathway evaluation: an approach for achieving and attributing impact in complex systems. *Agricultural Systems*, 78(2), 243–265. DOI: *https://doi.org/10.1016/S0308-521X(03)00128-8*

Fuchs, G., & **Hinderer, N.** (2016). Towards a low carbon future: a phenomenology of local electricity experiments in Germany. *Journal of Cleaner Production*, 128, 97–104. DOI: *https://doi.org/10.1016/j.jclepro.2016.03.078*

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, 31(8–9), 1257–1274. DOI: *https://doi.org/10.1016/S0048-7333(02)00062-8*

Gillich, A., Sunikka-Blank, M., & **Ford, A.** (2018). Designing an 'optimal' domestic retrofit programme. *Building Research & Information*, 46(7), 767–778. DOI: *https://doi.org/10.1080/09613218.2017.1368235*

Grin, J., Rotmans, J., & **Schot, J.** (2011). On patterns and agency in transition dynamics: Some key insights from the KSI programme. *Environmental Innovation and Societal Transitions*,1(1), 76–81. DOI: *https://doi.org/10.1016/j.eist.2011.04.008*

Gustafsson, S., Ivner, J., & **Palm, J.** (2015). Management and stakeholder participation in local strategic energy planning—Examples from Sweden. *Journal of Cleaner Production*, 98, 205–212. DOI: *https://doi.org/10.1016/j.jclepro.2014.08.014*

Hart van Brabant. (2015). *Op weg naar energieneutrale woningen*. Tilburg. *https://studylibnl.com/doc/1376155/deal-nul-op-de-meter-hart-van-brabant*

Hegger, D. L. T., Van Vliet, J., & **Van Vliet, B. J. M.** (2007). Niche management and its contribution to regime change: The case of innovation in sanitation. *Technology Analysis & Strategic Management*, 19(6), 729–746. DOI: *https://doi.org/10.1080/09537320701711215*

Hofman, P., & **Groenleer, M.** (2021). *Wijkaanpakken voor CO_2-reductie in de bestaande woningvoorraad. Eindrapport project SMILE* (Project Report). Tilburg University.

Hoogma, R., Kemp, R., Schot, J., & **Truffer, B.** (2002). *Experimenting for sustainable transport: The approach of strategic niche management*. Spon.

Kivimaa, P., Hyysalo, S., Boon, W., Klerkx, L., Martiskainen, M., & **Schot, J.** (2019). Passing the baton: How intermediaries advance sustainability transitions in different phases. *Environmental Innovation and Societal Transitions*, 31, 110–125. DOI: *https://doi.org/10.1016/j.eist.2019.01.001*

Klimaatakkoord. (2019). The Hague. *https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2019/06/28/klimaatakkoord/klimaatakkoord.pdf*

Kuzemko, C., & **Britton, J.** (2020). Policy, politics and materiality across scales: A framework for understanding local government sustainable energy capacity applied in England. *Energy Research & Social Science*, 62, 101367. DOI: *https://doi.org/10.1016/j.erss.2019.101367*

Laakso, S., Berg, A., & **Annala, M.** (2017). Dynamics of experimental governance: A meta-study of functions and uses of climate governance experiments. *Journal of Cleaner Production*, 169, 8–16. DOI: *https://doi.org/10.1016/j.jclepro.2017.04.140*

Loorbach, D., & **Rotmans, J.** (2006). Managing transitions for sustainable development. In Olsthoorn, X., & Wieczorek, A. (Eds.), *Understanding industrial transformation. Environment & policy*, 44, 187–206. Springer. DOI: *https://doi.org/10.1007/1-4020-4418-6_10*

Ministerie van Binnenlandse Zaken en Koninkrijsrelaties. (2011). *Plan van Aanpak Energiebesparing Gebouwde Omgeving*. The Hague. *https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2011/02/25/plan-van-aanpak-energiebesparing-gebouwde-omgeving/plan-van-aanpak-energiebesparing-gebouwde-omgeving-webversie.pdf*

Moore, M., Riddell, D., & **Vocisano, D.** (2015). Scaling out, scaling up, scaling deep: Strategies of non-profits in advancing systemic social innovation. *Journal of Corporate Citizenship*, 58, 67–84. DOI: *https://doi.org/10.9774/GLEAF.4700.2015.ju.00009*

Moss, T., Becker, S., & **Naumann, M.** (2014). Whose energy transition is it, anyway? Organisation and ownership of the Energiewende in villages, cities and regions. *Local Environment*, 20(12), 1547–1563. DOI: *https://doi.org/10.1080/13549839.2014.915799*

Omann, I., Kammerlander, M., Jager, J., Bisaro, A., & **Tàbara, J. D.** (2020). Assessing opportunities for scaling out, up and deep of win–win solutions for a sustainable world. *Climatic Change*, 160, 753–767. DOI: *https://doi.org/10.1007/s10584-019-02503-9*

PBL. (2014). *Energiebesparen gaat niet vanzelf: evaluatie energiebesparingsbeleid voor de gebouwde omgeving*. Planbureau voor de Leefomgeving (PBL). *https://www.pbl.nl/publicaties/energie-besparen-gaat-niet-vanzelf-evaluatie-energiebesparingsbeleid-voor-de-gebouwde-omgeving*

Rijksoverheid Nederland. (2020). *Klimaatwet*. *https://wetten.overheid.nl/BWBR0042394/2020-01-01*

Rip, A., & **Kemp, R.** (1998). Technological change. In S. Rayner, & E. L. Malone (Eds.), *Human choice and climate change—Resources and technology* (pp. 327–399). Battelle.

Rosenow, J., Kern, F., & **Rogge, K.** (2017). The need for comprehensive and well targeted instrument mixes to stimulate energy transitions: The case of energy efficiency policy. *Energy Research & Social Science*, 33, 95–104. DOI: *https://doi.org/10.1016/j.erss.2017.09.013*

Scottish Government. (2017). *Scotland's Energy Efficiency Programme: Second consultation on local heat and energy efficiency strategies, and regulation of district and communal heating*. *https://www.gov.scot/binaries/content/documents/govscot/publications/consultation-paper/2017/11/scotlands-energy-efficiency-programme-second-consultation-local-heat-energy-efficiency/documents/00527606-pdf/00527606-pdf/govscot%3Adocument/00527606.pdf*

Scottish Government. (2018). *Energy efficient Scotland: Route map*. *https://www.gov.scot/publications/energy-efficient-scotland-route-map/*

Scottish Government. (2021). *Heat in buildings strategy—Achieving net zero emissions: consultation*. *https://www.gov.scot/publications/heat-buildings-strategy-achieving-net-zero-emissions-scotlands-buildings-consultation/*

Sengers, F., Wieczorek, A., & **Raven, R. P. J. M.** (2019). Experimenting for sustainability transitions: A systematic literature review. *Technological Forecasting & Social Change*, 145, 153–164. DOI: *https://doi.org/10.1016/j.techfore.2016.08.031*

Seyfang, G., & **Smith, A.** (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics*, 16(4), 584–603. DOI: *https://doi.org/10.1080/09644010701419121*

Sturzaker, J., & **Gordon, M.** (2017). Democratic tensions in decentralised planning—Rhetoric, legislation and reality in England. *Environment and Planning C: Politics and Space*, 35(7), 1324–1339. DOI: *https://doi.org/10.1177/2399654417697316*

Tingey, M., & **Webb, J.** (2020). Governance institutions and prospects for local energy innovation: Laggards and leaders among UK local authorities. *Energy Policy*, 138, 111211. DOI: *https://doi.org/10.1016/j.enpol.2019.111211*

UK Parliament. (n.d.) *Introduction to Devolution in the UK*. House of Commons Library. *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770300/IntroductionToDevolution.pdf*

Van den Bosch, S. (2010). *Transition experiments: Exploring societal changes towards sustainability*. Erasmus University Rotterdam. *http://hdl.handle.net/1765/20714*

Van den Bosch, S., & **Rotmans, J.** (2008). *Deepening, broadening and scaling up: A framework for steering transition experiments*. Delft: Knowledge Centre for Sustainable System Innovations and Transitions (KCT). *https://transitiepraktijk.nl/files/Broadening,%20deepening,%20scaling%20up.pdf*

Wade, F., & **Webb, J.** (2020). *LHEES phase 2 pilots: Evaluation report* (Report to Scottish Government). *https://www.gov.scot/publications/local-heat-energy-efficiency-strategies-lhees-phase-2-pilots-evaluation/*

Wade, F., Webb, J., & **Creamer, E.** (2019). *Local heat and energy efficiency strategies: Phase 1 pilots. Social evaluation report* (Report for Scottish Government). *https://www.gov.scot/publications/local-heat-energy-efficiency-strategies-phase-1-pilots-social-evaluation/*

TO CITE THIS ARTICLE:
Hofman, P., Wade, F., Webb, J., & Groenleer, M. (2021). Retrofitting at scale: comparing transition experiments in Scotland and the Netherlands. *Buildings and Cities*, 2(1), pp. 637–654. DOI: *https://doi.org/10.5334/bc.98*

Submitted: 12 January 2021
Accepted: 14 June 2021
Published: 13 July 2021

Buildings and Cities is a peer-reviewed open access journal published by Ubiquity Press.